

NAFEC TECHNICAL LETTER REPORT

NA-78-69-LR

THE BEHAVIOR OF WIDE BODY AIRCRAFT EMERGENCY
EXIT SIGNS AT ELEVATED AIR TEMPERATURES

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ABSTRACT

This report presents the results of an evaluation of the performance of various wide body emergency aircraft exit signs while subjected to elevated temperatures ranging from ambient to 350° F. A description is given of the equipment and procedures used to conduct this evaluation. Since some of the signs experienced various types and degrees of failures, performance at elevated temperatures may be an additional criteria needed for exit sign certification.

INTRODUCTION

PURPOSE.

The purpose of this report is to (a) evaluate certain wide body aircraft emergency exit signs at elevated temperatures, (b) describe the equipment and procedures used to conduct this evaluation, and (c) report any operational malfunctions in the signs at these conditions.

BACKGROUND.

The Federal Aviation Administration (FAA) does not specify the temperature range that emergency interior signs must operate under. Preliminary fire tests conducted in the C-133 wide body test article to evaluate present and future emergency interior exit lighting systems repeatedly indicated a "failure" of an exit sign under thermal conditions that may be considered survivable. In one test exit sign illumination ceased after 65 seconds at an ambient temperature near the sign of 295° F. Later tests indicated the same sign could "fail" with ambient air temperatures as low as 210° F. In some tests only partial illumination was lost. Failure was considered to have occurred with the extinguishment of any one or more of the 12 miniature lamps which illuminate the word "EXIT" on the sign cover. These findings were transmitted in a letter to ARD-500.

Although it was determined that the failed sign was not used in any U.S. commercial wide body aircraft, a request was received by letter from AFS-120 (through ARD-520) to test cabin threshold lights from each of the L-1011, DC-10 and B-747 airplanes "under C-133 cabin thermal conditions which cause a similar light to fail." This report describes the results of this requested study.

DISCUSSION

DESCRIPTION OF TEST SIGNS.

Six different types of exit signs were tested. Manufacturer use and other pertinent data is shown in table 1.

TEST PREPARATION AND ARRANGEMENT.

The exit signs were tested in an electric oven, which provided a controllable thermal environment. A suitable support stand was fabricated for each sign and the holes designed for aircraft mounting were utilized for securing the sign to the stand.

Two 28 AWG chromel/alumel thermocouples were installed in the interior of each sign except the Symbolic Display sign. The construction of this sign would not permit installation of an internal thermocouple. Two 28 AWG chromel/alumel thermocouples were installed in the test oven to measure ambient oven temperature. These thermocouples were connected to an Esterline Angus D 2020 digital recorder and the temperature data was recorded at 20-second intervals throughout the tests.

The electric oven used for these tests has dimensions of 13 inches wide, 13 inches high and 29 1/2 inches deep. The oven door was replaced by a Pyrex window which enabled observations and photographic coverage during the test. Prior to subjecting the signs to the elevated temperature environment, the oven was calibrated and various time/temperature data were generated. It was decided to raise the temperature at 20°F increments from ambient to 350° F. The upper limit roughly approximates the thermal tolerance limit for humans for exposures of several minutes (the opinions regarding this thermal limit varies considerably in the literature). The automatic oven temperature controller was used to raise the oven temperature. The set temperature was increased by 20° F after the oven temperature stabilized out. Using this procedure, it took about 20.6 - 26.4 minutes to raise the oven temperature from ambient to 350° F. Due to the limited volume of the oven chamber, it was necessary to perform three tests to examine the six types of signs. It was not possible to exactly match the temperature-time curves for the three tests, apparently because of different heat sink or air volume effects from the various signs.

The manufacturers recommended rated voltage was provided to the various signs by a direct current (DC) power supply and this was monitored by a DC voltmeter.

TEST RESULTS.

Three signs, Luminator A, Luminator B and Grimes P/N 10-04823-3 were tested first. All three signs displayed no distortion or loss of illumination through eleven minutes of the test, corresponding to a temperature of 212°F. At this time Luminator A began to distort and bow out in the area of the "XI". More deformation was observed at 13.3 minutes (230°F) and continued until one of the sides of the sign dropped off completely at 21 minutes (286°F). There was no loss of any lamp illumination during this time.

The Luminator B sign withstood the thermal environment until 23 minutes (320°F), when it was observed that the appearance of the sign face was very flimsy and flexible. However, no further distortion was noted when the test was terminated at 26 minutes (358°F).

The Grimes 10-0482-3 sign indicated only slight deformation during the complete test and no loss of illumination was noted. The signs were allowed to cool and then removed from the test oven for photographic documentation to show damage and distortion.

The Grimes P/N 10-0705-1 sign and the Symbolic Displays P/N 700311-1 sign were evaluated during the second test. The Grimes sign had been used during prior evaluation and failed immediately after the start of the test (110°F). Failure consisted of loss of illumination of all of the 12 lamps used in the "EXIT" area. This loss of illumination was due to the distortion of the "EXIT" cover pulling the individual lamps away from their electrical contact area. The threshold lights remained lighted since they are "hard wired" into the sign fixture.

The Symbolic Displays sign behaved satisfactorily until lamps 1, 2, and 3 (starting on the "E" side of the face) displayed a loss of illumination at 18.3 minutes (346° F). There was very little distortion of the sign face and the reason for the lamp failures could not be determined. The test was terminated at 23 minutes (365° F), the signs allowed to cool and then removed for photographic documentation.

The third test was conducted with a Grimes P/N 10-0705-13 sign (modified version of P/N 10-0705-1) and an unused Grimes P/N 10-0705-1 sign. The 10-0705-13 was designed by Grimes to alleviate the illumination malfunctions experienced by the 10-0705-1 in the heated air environment during preliminary C-133 tests. The 10-0705-1 sign failed in the same manner as before; the cover distorted and pulled away from the base, breaking the electrical circuit. This occurred after 2 minutes of testing and at an oven ambient temperature of only 140° F. At this time the internal temperatures of this sign were 116° F and 125° F, consistent with all previous tests on this sign, the "hard wired" threshold lights remained lighted throughout the test. The first malfunction of the 10-0705-13 light occurred at 4.3 minutes (175° F) when the number 3 lamp near the "E" went out. The internal temperature was 141° F. This lamp came back on at 4.6 minutes (170° F), with an internal temperature of 145° F, and remained on until 10.0 minutes (225° F), with an internal temperature of 210° F. At 10 minutes the light extinguished, it came back on 0.3 minutes later and remained on until 16 minutes (315° F) when it began flickering. The lamp remained on steady for the remainder of the test. The test was terminated at 20.6 minutes (355° F). At the end of the test, internal temperature in the 10-0705-13 was 330° F and 331° F, and 330° F and 344° F in the 10-0705-1 sign.

The signs were allowed to cool and then removed for photographic documentation. The 10-0705-1 sign cover was badly deformed which apparently was the cause of the early failure. The 10-0705-13 sign was only slightly deformed after the test, indicating that the Grimes modification was successful in prolonging the sign's operational life under elevated thermal conditions. A summary of these observations is shown in table 2.

SUMMARY OF FINDINGS

1. The loss in exit sign illumination experienced at elevated temperatures in the C-133 preliminary cabin fire tests was not found in follow-on tests, described in this report, on four types of wide body exit signs. Three of the four signs remained illuminated throughout the test duration (final oven temperature of 350° F), while the remaining sign lost only partial illumination practically at the end of the test (346° F).
2. The plastic covers on the four wide body exit signs experienced different amounts of heat distortion. For example, two signs distorted very little over the entire test, one sign appeared "flimsy" at a relatively high temperature (320° F), while the remaining sign distorted early into the test (212° F) and one side collapsed at 286° F.
3. The loss of illumination of the sign type which failed in the C-133 was even more pronounced in the oven tests. Failure was observed at a much lower temperature (140° F versus 210 - 295° F) and consisted of extinguishment of all 12 miniature lamps. Failure was attributed to a loss of electrical contact resulting from distortion of the plastic cover.
4. The modified exit sign (10-0705-13) displayed a substantial improvement in performance over that experienced in both the preliminary C-133 and oven tests. Distortion of the cover was minimal over the test duration and only one miniature lamp intermittently extinguished over the test duration, but was illuminated at the end of the tests. The remaining 11 lamps were illuminated throughout the test.

This evaluation was conducted in response to a letter request from ARD-520 (through AFS-120) February 3, 1978, to test the exit signs under conditions that caused similar signs to fail in the C-133 cabin thermal environment. The project number is 181-521-100 and the NAFEC Program Manager is Constantine Sarkos. Further information can be obtained from James Demaree, ANA-420, (609) 641-8200 extension 3078.

TABLE I

MANUFACTURER: MIDLAND ROSS-GRIMES DIV.

PART NUMBER: 10-0705-1 & 10-0705-13

USE: OVER EXIT DOOR-THRESHOLD ILLUMINATION

AIRCRAFT: COMMAND POST B-747

DESCRIPTION: 2-"HARD WIRED" LAMPS FOR THRESHOLD ILLUM. 12-MINATURE LAMPS FOR "EXIT" ILLUMINATION

TEST NUMBER: 2 & 3

MANUFACTURER: SYMBOLIC DISPLAYS

PART NUMBER: 700311-1 SER. NO. 074

USE: OVER EXIT DOOR.

AIRCRAFT: BOEING 747

DESCRIPTION: 7PR. MINATURE LAMPS FOR "EXIT" ILLUMINATION-(7 REG. & 7 EMERG.)

TEST NUMBER: 2

MANUFACTURER: LUMINATOR

PART NUMBER: UNKNOWN (A) TEST PURPOSE ONLY

USE: OVER AISLE: EXIT LOCATOR

AIRCRAFT: DOUGLAS DC-10

DESCRIPTION: 6 LAMPS FOR "EXIT" ILLUMINATION
1 LAMP FOR THRESHOLD ILLUMINATION

TEST NUMBER: 1

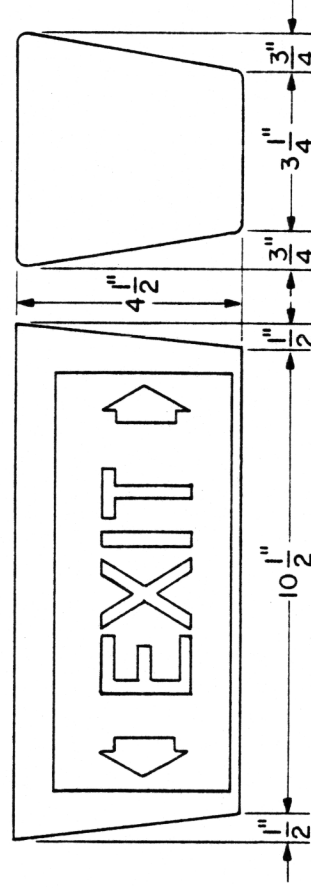
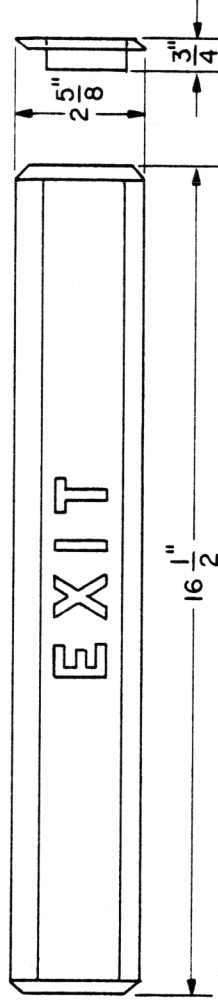
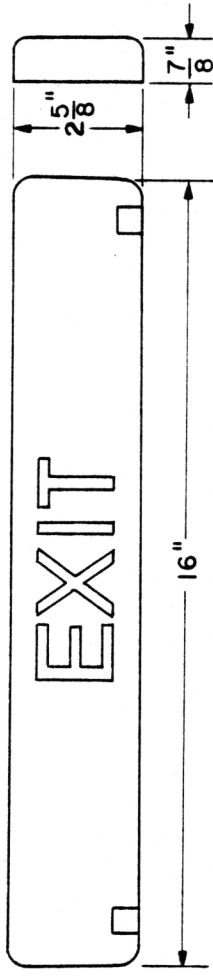
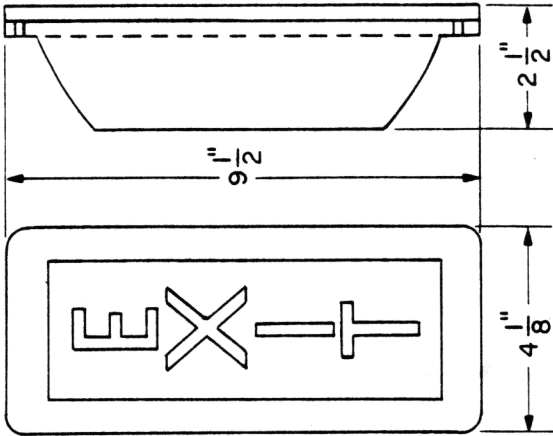


TABLE I continued

MANUFACTURER: LUMINATOR
PART NUMBER: L20482 SER. NO. 788621 TEST
PURPOSE ONLY
USE: EXIT IDENTIFICATION
AIRCRAFT: DOUGLAS DC-10
DESCRIPTION: 3 LAMPS FOR EXIT ILLUMINATION
TEST NUMBER: 1



MANUFACTURER: MIDLAND ROSS-GRIMES DIVISION
PART NUMBER: 10-0482-3
USE: EXIT IDENTIFICATION
AIRCRAFT: LOCKHEED L1011
DESCRIPTION: 8 LAMPS FOR "EXIT" ILLUMINATION
4-NORMAL--4 EMERGENCY USE
TEST NUMBER: 1

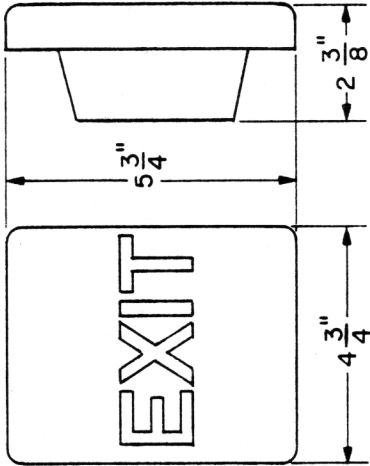


TABLE 2 - SUMMARY OF TEST OBSERVATIONS

OBSERVATIONS*

SIGN	TEST NO.	MECHANICAL	ILLUMINATION
LUMINATOR A **	1	212°F First Distortion 286°F Collapse of one side	Complete illumination throughout test.
LUMINATOR B **	1	320°F Face appeared flimsy and flexible 358°F Appearance unchanged	Complete illumination throughout test.
GRIMES P/N/ 10-0482-3 **	1	Slight deformation over test duration.	Complete illumination throughout test.
SYMBOLIC DISPLAYS ** P/N 700311-1	2	Very little distortion throughout test.	346°F, 3 of 7 miniature lamps extinguished.
GRIMES, *** P/N/ 10-0705-1	2	110°F Distortion of cover.	110°F, Loss of illumination of 12 miniature lamps (beginning of test)
GRIMES P/N/ 10-0705-1	3	140°F Distortion of cover.	140°F, Loss of illumination of 12 miniature lamps.
GRIMES P/N 10-0705-13	3	Slight deformation over the test duration.	175°F--#3 lamp out 200°F--#3 lamp back on (0.3 minutes later) 255°F--#3 lamp out 249°F--#3 lamp back on (0.3 minutes later) 315°F--#3 lamp flickering, then steady illumination until test termination.

* Temperatures refer to thermocouple oven air temperature.

** Commercial wide body transport usage

*** May have been damaged during prior evaluation.

APPENDIX

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